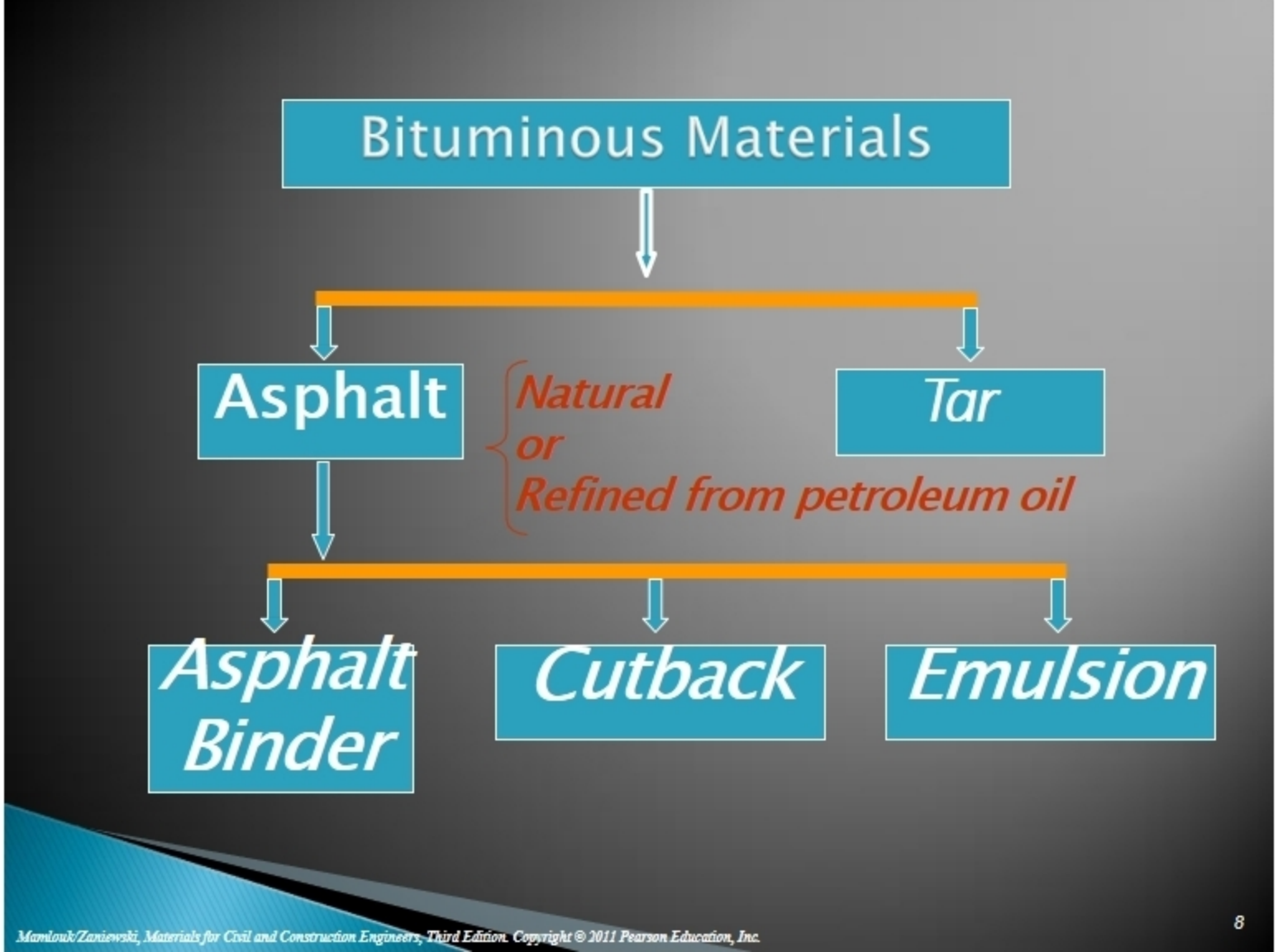
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What is Asphalt?

"A dark brown to black cementitious material in which the predominating constituents are bitumens which occur in nature or are obtained in petroleum processing –**ASTM**

In *British English*, the word asphalt refers to a mixture of mineral aggregate and bitumen.

In *American English*, bitumen is referred to as 'asphalt' or 'asphalt cement' .

(Sourced)

Bituminous Materials

- Asphalt cement and tar are considered bituminous materials.
- Asphalt cement and tar are two distinctly different materials with different origins and different chemical and physical characteristic

Tar is not Asphalt

- Asphalt cement is a dark brown to black cementitious materials either it is naturally occurred or produced by petroleum distillation
- Tar however, is primarily manufactured from the destructive distillation of bituminous coal and has a very distinct odor, brown-black in color
- Petroleum asphalt is composed entirely of bitumen, whereas in coal tar bitumen content is relatively low
  - Asphalts will be dissolved in petroleum oils whereas tars will not
  - Therefor tars have been used to seal asphalt concrete surfaces, such as fog seals, to improve the oil resistance of asphalt surfaces

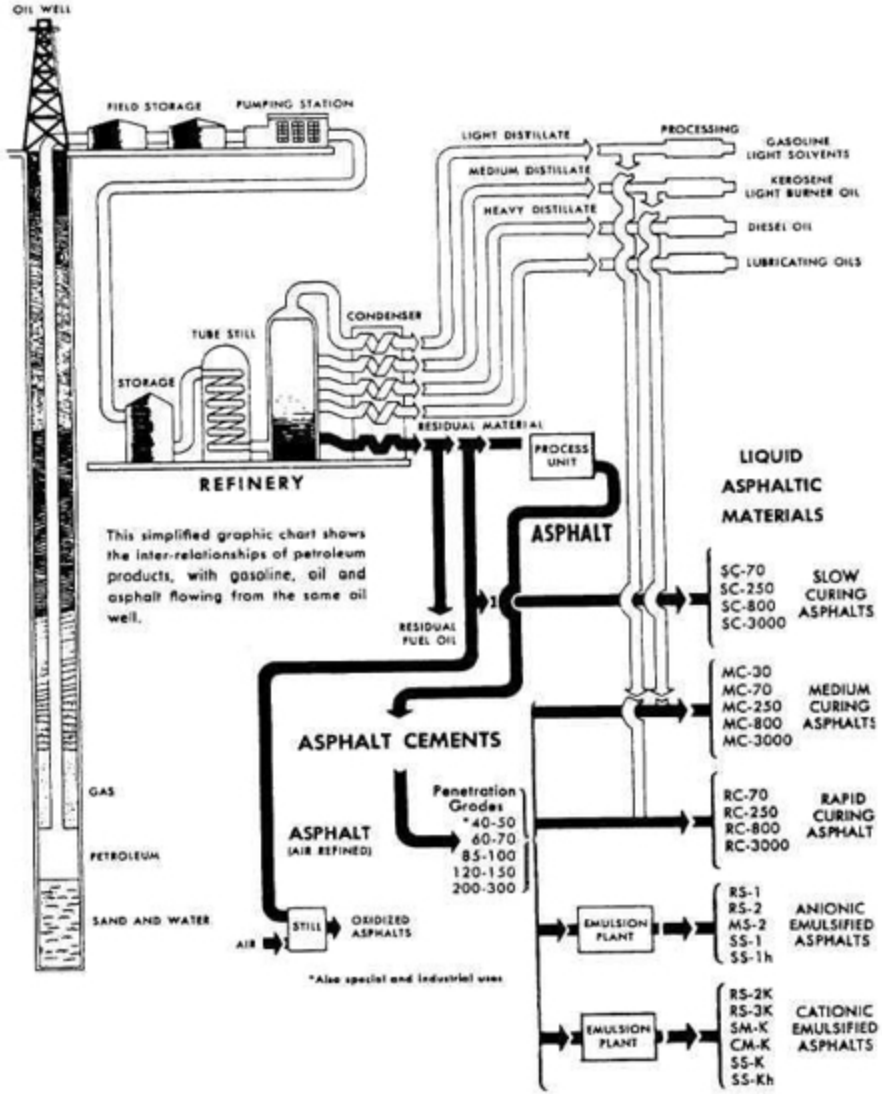
Tar is hardly used in paving. Why? (Sourced)

1. Some undesirable physical characteristic such as very high temperature susceptibility
2. Susceptible to weathering
3. Significant health hazards such as severe eye and skin irritation when exposed to its fume

Comparison between Bitumen and Tar

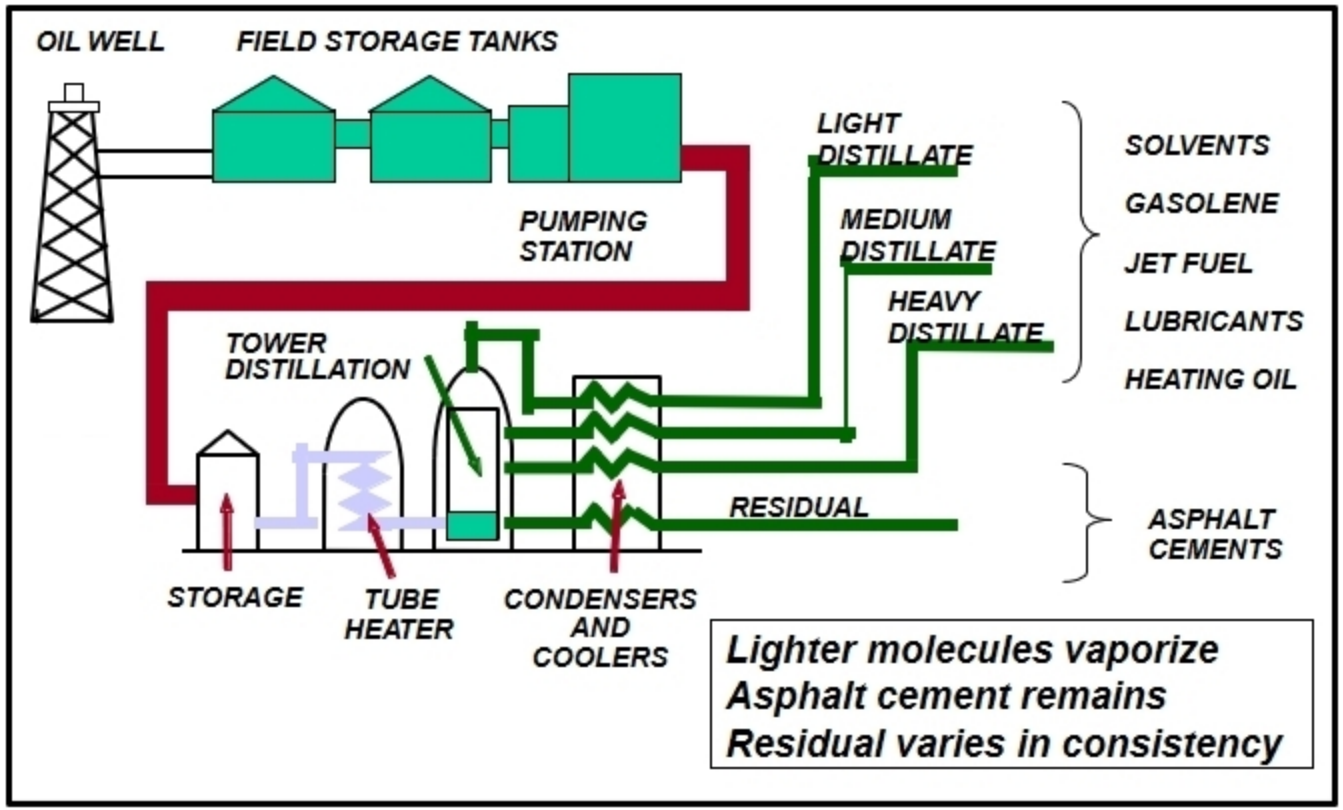
Bitumen	Tar
Adhesion between aggregate and bitumen is less and does not retain well in presence of water	Produced by destructive distillation of coal or wood
Adhesion between aggregate and bitumen is less and does not retain well in presence of water	Adhesion between aggregate and tar is more and retain well in presence of water than bitumen
Weather resisting property is quite good	Has inferior weather resisting property
Less susceptible to temperature	More susceptible to temperature
Cost is high and useful for road construction	Cheaper than bitumen and useful for roofing materials and filler
Setting time is less	Setting time is more
Hardens very slowly	Hardens at much faster rate than bitumen

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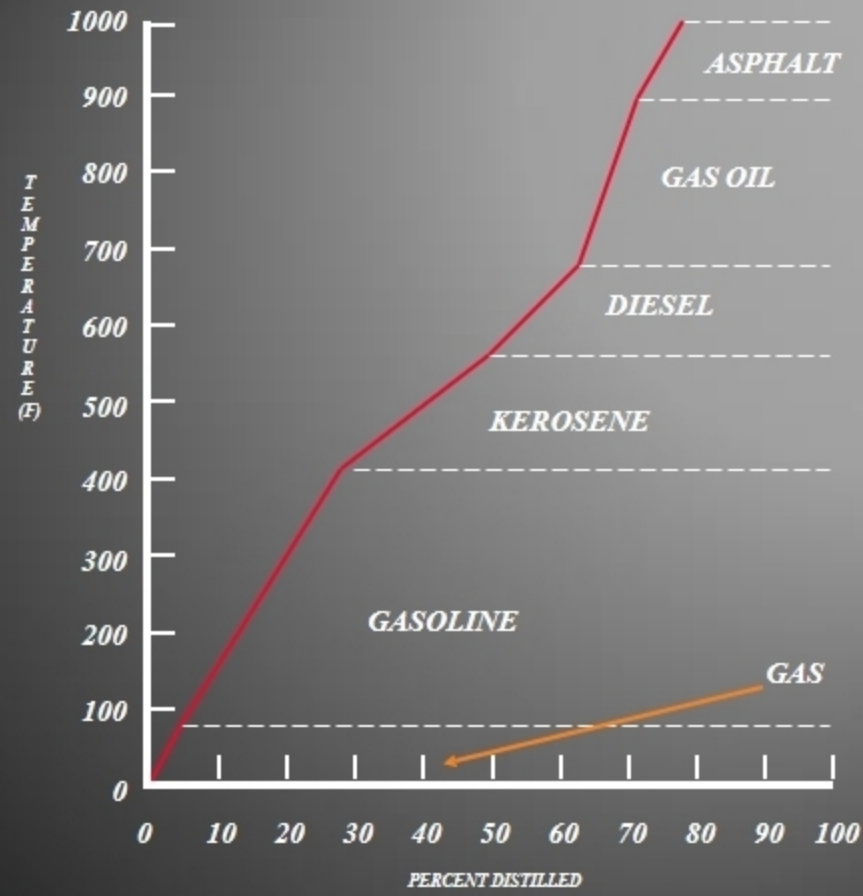

OIL WELL
FIELD STORAGE
PUMPING STATION
LIGHT DISTILLATE
MEDIUM DISTILLATE
HEAVY DISTILLATE
PROCESSING
GASOLINE LIGHT SOLVENTS
KEROSENE LIGHT BURNER OIL
DIESEL OIL
LUBRICATING OILS
CONDENSER
TUBE STILL
STORAGE
RESIDUAL MATERIAL
PROCESS UNIT
REFINERY
This simplified graphic chart shows the inter-relationships of petroleum products, with gasoline, oil and asphalt flowing from the same oil well.
ASPHALT
LIQUID ASPHALTIC MATERIALS
SC-70
SC-250
SC-800
SC-3000
SLOW CURING ASPHALTS
RESIDUAL FUEL OIL
MC-30
MC-70
MC-250
MC-800
MC-3000
MEDIUM CURING ASPHALTS
ASPHALT CEMENTS
Penetration Grades
*40-50
60-70
85-100
120-150
200-300
RC-70
RC-250
RC-800
RC-3000
RAPID CURING ASPHALT
GAS
PETROLEUM
SAND AND WATER
ASPHALT (AIR REFINED)
AIR
STILL
OXIDIZED ASPHALTS
EMULSION PLANT
RS-1
RS-2
MS-2
SS-1
SS-1h
ANIONIC EMULSIFIED ASPHALTS
EMULSION PLANT
RS-2K
RS-3K
SM-K
CM-K
SS-K
SS-Kh
CATIONIC EMULSIFIED ASPHALTS
*Also special and industrial uses

(Sourced)

Refinery Operation



(Sourced)


1000
900
800
700
600
500
400
300
200
100
0
TEMPERATURE (F)
ASPHALT
GAS OIL
DIESEL
KEROSENE
GASOLINE
GAS
0
10
20
30
40
50
60
70
80
90
100
PERCENT DISTILLED

(Sourced)

Classification of Asphalt

Asphalt commonly used in flexible pavement construction and can be divided into three (3) general types:

1. Asphalt cement
2. Emulsified asphalt
3. Cutback asphalt

(Sourced)

Asphalt Cements

- Asphalt cement is a viscoelastic material
- **The extent to which asphalt cement behaves as a viscous material or elastic material is dependent on the temperature and rate of loading**
- For example, asphalt cement at 60^0C may flow the same amount in 1 hour as it would be at 25^0C in 5 hour
- **At high temperatures under slow loading condition** (slow moving traffic), asphalt cement behaves like a **viscous fluid and flow**
- This is called plastic behavior that may lead to permanent deformation to pavement. It should be noted that aggregates play a significant role in resisting permanent deformation
- **At low temperature and rapid loads (fast moving traffic)**, asphalt cement behaves like **elastic solids**
- **At intermediate temperature,** asphalt cement exhibits **both viscous and elastic behavior**

(Sourced)

Emulsified and Cutback Asphalt

Can we pump asphalt without heating?

Can we mix the asphalt with aggregates without by heating?

Yes, there are ways, other than heating to liquefy asphalt for construction operations. **Asphalt can be dissolved in selected petroleum solvents or emulsified agent and water. Asphalt liquefied by these methods is known as cutback asphalt and emulsified asphalt**

For **cutback asphalt,** after completion of construction, the **solvent will evaporate**, leaving the asphalt cement to perform its function

With **emulsified asphalt**, the basic idea is that **water will evaporate, leaving the asphalt cement to perform its function**

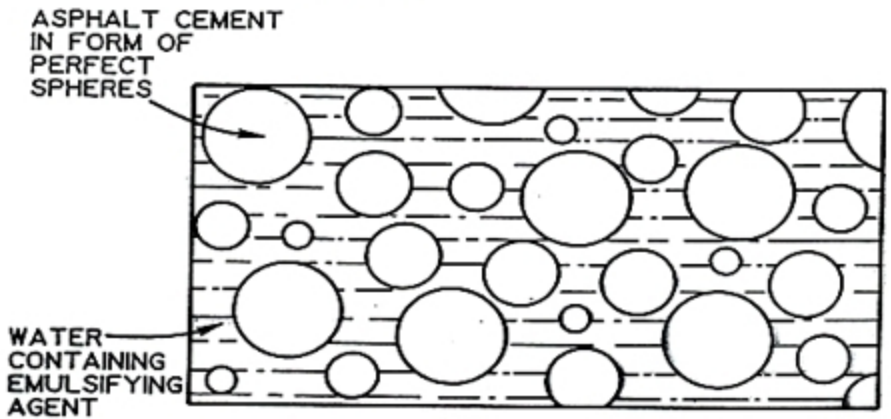
In each case asphalt cement is the base material liquefied by emulsifying or cutting back

Bitumen emulsions are ideal binders for hill road construction where heating of bitumen or aggregates are difficult.

Emulsified asphalt

(Sourced)

- Emulsified asphalt is a mixture of asphalt cement, water, and emulsifying agent
- **Since the asphalt cement will not dissolve in water, asphalt cement and water exist in separate phases as shown in the following figure:**



Emulsified Asphalt

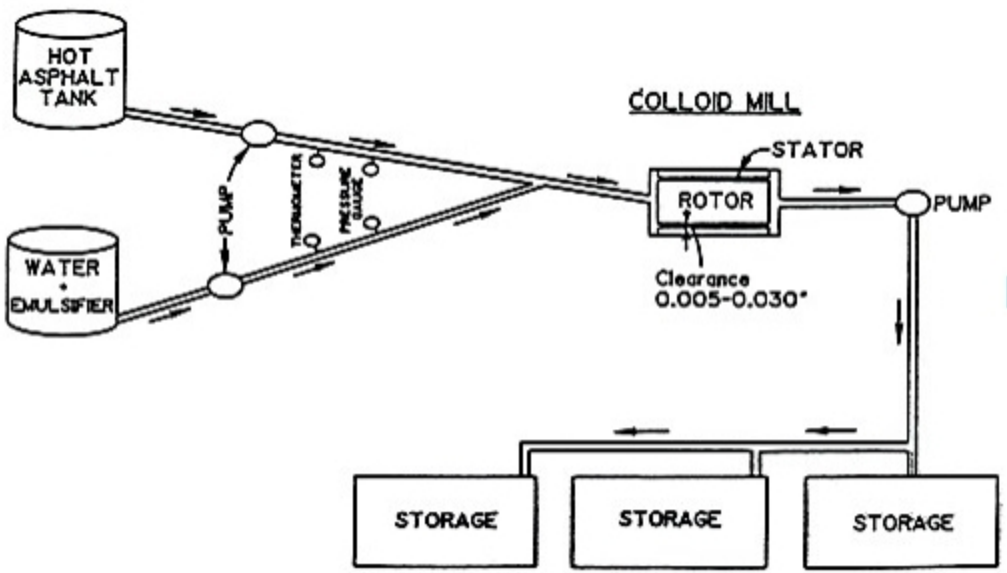
- **To mix the asphalt cement with water, an emulsifying agent (usually a type of soap) is added**

Some commonly used emulsifying agents include tragacanth, sodium laurylsulfate, sodium dioctyl sulfosuccinate, and polymers known as the Spans® and Tweens®.

(Sourced)

Emulsified asphalt-----contd.

Process of manufacture of emulsified asphalt consists passing the hot asphalt cement and water containing the emulsifying agent under pressure through a colloid mill, as shown in the following



Manufacture of Emulsified Asphalt

- **The colloid mill breaks up the asphalt cement and disperses it, in the form of very fine droplets/globules (5-10 microns and smaller), in the water carrier**
- **The emulsion contains usually 55-75% asphalt cement and up to 3% emulsifying agent, balance being water**

Specifications for Emulsified asphalt

(Sourced)

- Two most commonly used types of emulsified asphalts are specified in ASTM D977 and ASTM D2397:
  - Anionic – electro-negatively charged asphalt droplets
  - Cationic – electro-positively charged asphalt droplets
    - Emulsifier gives surface charge to asphalt
    - Opposite charges attract aggregate particles

- Anionic emulsions adhere better to aggregate particles with positive surface charges (e.g., limestone)

- Cationic emulsions adhere better to aggregate particles with negative surface charges (e.g., sandstone, quartz, siliceous gravel). Cationic emulsions also work better with wet aggregates and in colder weather

Three types of bituminous emulsions:
Rapid setting (RS) - used for surface dressing work
Medium setting (MS) - are preferred for premix jobs and patch repairs work
Slow setting (SC) - preferred in rainy season.

Cutback Bitumen/Asphalt

(Sourced)

Normal practice is to heat bitumen to reduce its viscosity. In some situations, preference is given to use liquid binders such as cutback bitumen. In cutback bitumen suitable solvent is used to lower the viscosity of the bitumen.

The solvent from the bituminous material will evaporate and the bitumen will bind the aggregate.

Cutback bitumen is used for cold weather bituminous road construction and maintenance.

The distillates used for preparation of cutback bitumen are naphtha, kerosene, diesel oil, and furnace oil.

There are different types of cutback bitumen

Rapid curing (RC) - recommended for surface dressing and patchwork

Medium curing (MC) - recommended for premix with less quantity of fine aggregates

Slow curing (SC) - used for premix with appreciable quantity of fine aggregates.

(Sourced)

Emulsified asphalts are increasingly being used in lieu of cutback asphalts for the following reasons:

- **Environmental regulations:** Emulsions are relatively pollution free
- **Loss of high-energy products:** When cutback asphalts cure, the diluents which are high energy, high price products are wasted into atmosphere
- Safety: Emulsions are safe to use
- **Lower application temperature:** Emulsions can be applied at relatively low temperatures saving the fuel costs. Emulsions can also be applied effectively to a damp pavement, whereas dry conditions are required for cutback asphalts

(Sourced)

TESTS FOR ASPHALTIC MATERIALS

- General
  - Specific gravity
  - Flash point (open cup)
  - Water in petroleum products
- Solubility
  - Solubility of bituminous materials
  - Spot test
- Consistency
  - Specific Viscosity
  - Kinematic viscosity
  - Absolute viscosity
  - Float test
  - Penetration
  - Softening point (ring-and-ball method)
- Ductility
  - Ductility
- Volatility
  - Distillation
  - Loss on heating
  - Thin-film oven test
  - Tests for emulsion

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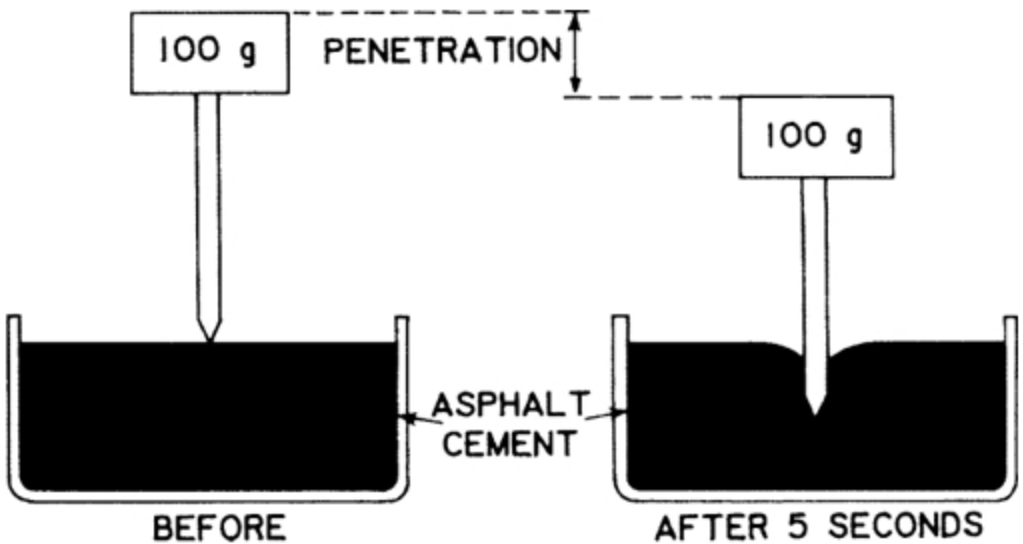
Penetration Test

- In this procedure, a needle is typically loaded with a 100 g weight and allowed to penetrate into an asphalt cement sample for 5 sec at 25^0C
- A harder asphalt will have a lower penetration while a softer asphalt cement will have a higher penetration

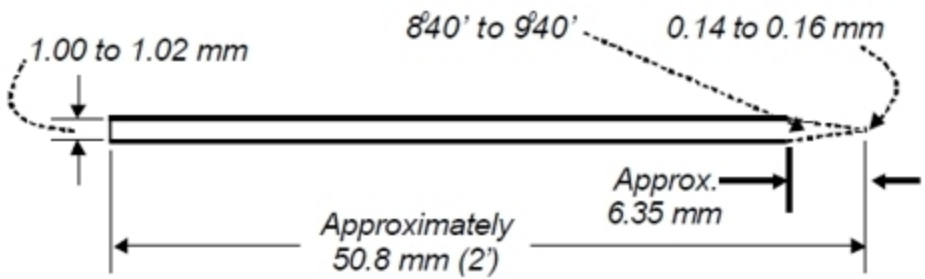
  - Five penetration grades
    - 40-50 = stiffest
    - 60-70
    - 85-100
    - 120-150
    - 200-300 = softest

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Penetration Test (ASTM D5)





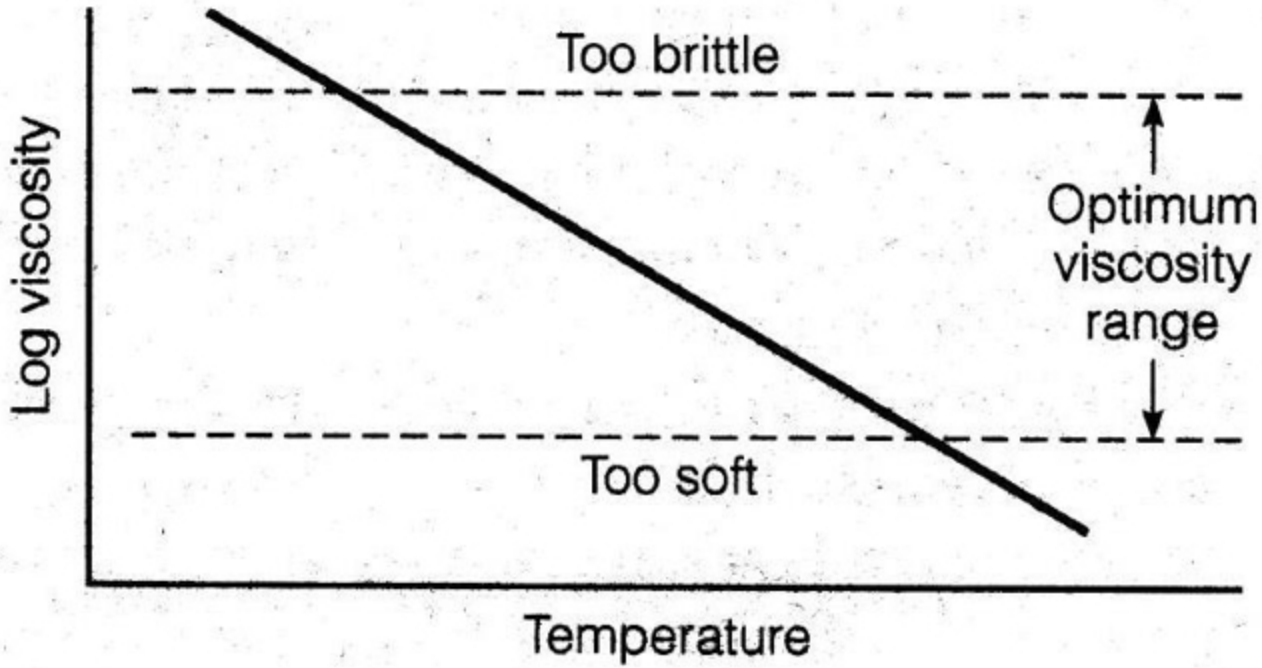


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Viscosity

- Viscosity is reverse of fluidity. It is a measure of the resistance to flow
- Higher the viscosity of liquid bitumen, the more nearly it approaches a semi-solid state in consistency
- The bitumen binders of low viscosity, simply lubricate the aggregate particles instead of providing a uniform thin film for binding action
- High viscosity does not allow full compaction and the resulting mix exhibits heterogeneous character and thus low stability values.

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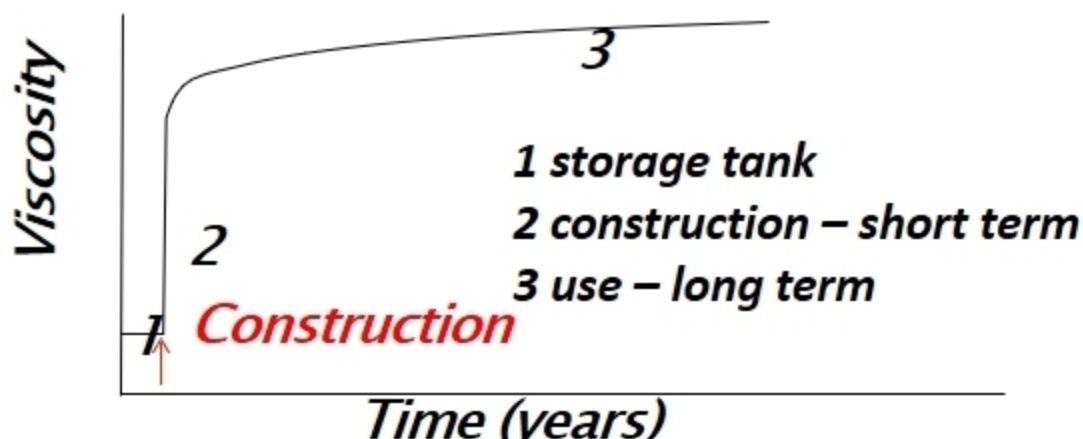

Too brittle
Optimum viscosity range
Too soft
Log viscosity
Temperature

Aging Behavior

(Sourced)

Aging or hardening is the process under which asphalt becomes harder and brittle due to increase in the viscosity of asphalt caused by:

- the evaporation and oxidation of the lighter, oily constituents during mixing at high temperatures, called "volatilization" (short-term aging or hardening)
- the oxidation of the oils to resins and resins to asphaltenes when used over a period of years (long-term or in-service aging or hardening)



(Sourced)

Bituminous mix design

The bituminous mix design aims to determine the **proportion of bitumen, filler, fine aggregates, and coarse aggregates to produce a mix which is workable, strong, durable and economical.**

Constituents of a mix

- Coarse aggregates: Offer compressive and shear strength and shows good interlocking properties.
- Fine aggregates: Fills the voids in the coarse aggregate and stiffens the binder.
- Filler: Fills the voids, stiffens the binder and offers permeability

Binder: Fills the voids, cause particle adhesion and gluing and offers impermeability.

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Marshall Mix Design

The mix design (wet mix) determines the optimum bitumen content.

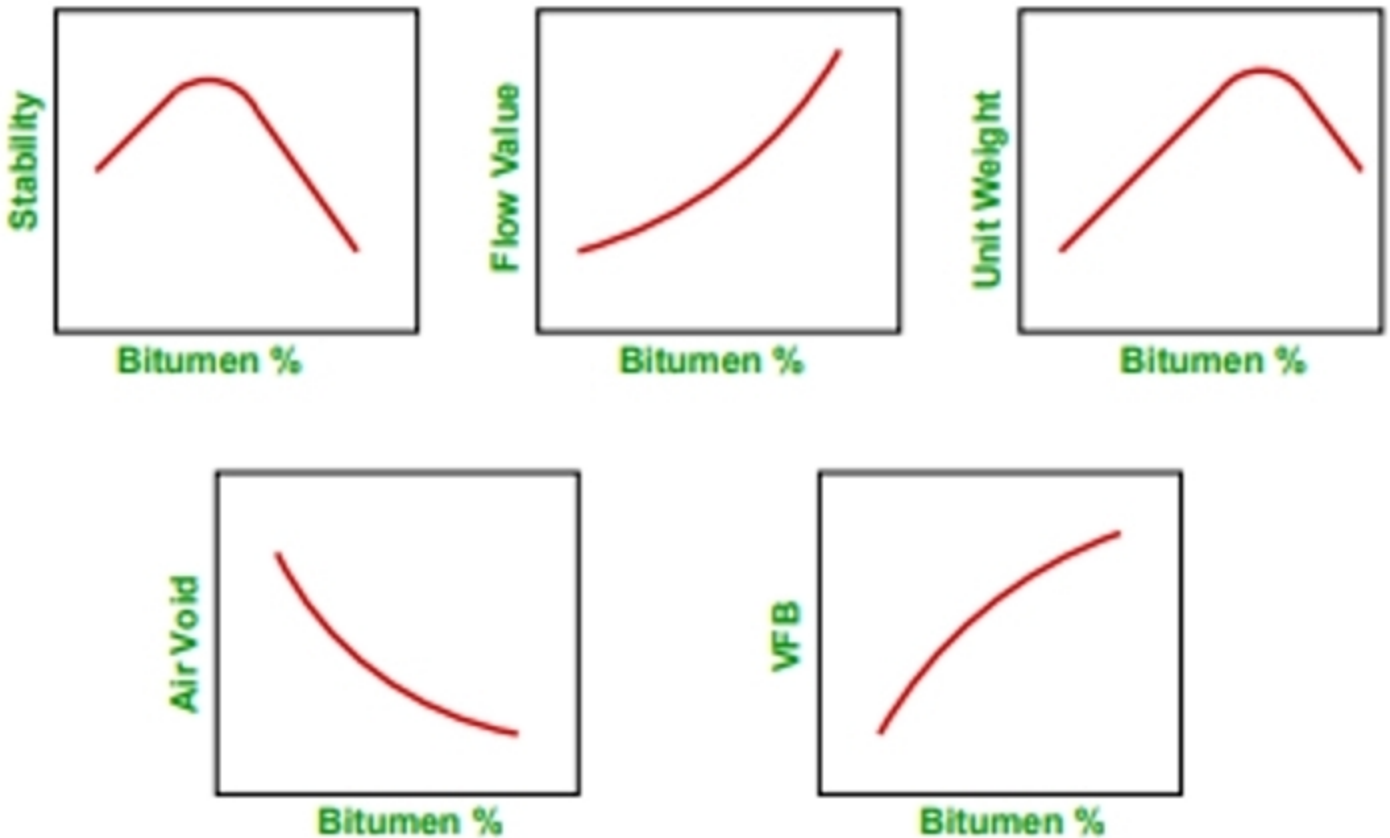
Stability and flow test

The stability measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute.

The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded.

(Sourced)

Marshall Mix Design



(Sourced)

(Sourced)

CT 2

1. Give 3 examples of green transport mode. Mention minimum three measures required for encouraging green transport 4
2. What quality of aggregate is tested by LAA test? 2
3. Name the tests for consistency parameter of Bitumen/Asphalt. 3
4. How asphalt cement behave at high, low and moderate temperature? 3
5. Mention the objective of Bitumen mix design. 2
6. Draw the qualitative curves between (a) bitumen (%) vs stability and (b) bitumen (%) vs flow. 6